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(54) Title: METHOD FOR DRILLING AND CEMENTING A WELL

(57) Abstract

A borehole is drilled utilizing an oil-in-water emulsion drilling fluid, optionally containing blast furnace slag. A compatible cementitious slurry containing blast furnace slag and an activator system is then introduced into the borehole and displaced up into an annulus. Generally, the cementitious slurry is prepared by adding additional blast furnace slag and an activator such as a sodium hydroxide/sodium carbonate mixture to the used drilling fluid.

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METHOD FOR DRILLING AND CEMENTING A WELL

This invention relates to drilling and cementing a well.

The rotary drilling of a borehole is accomplished using a rotary drilling assembly comprising a by rotating a drill bit attached to the lower end of a drill string. Weight is applied to the drill bit while rotating to create a borehole into the earth. The drill string is hollow and pipe sections are added to the drill string to increase its length as the borehole is deepened. In rotary drilling the drill bit can be rotated by rotating the drill string and/or by driving a downhole motor arranged at the lower end of the drill string.

This rotary drilling process creates significant amounts of friction which produces heat along with fragments of the strata being penetrated. The fragments of the strata must be removed from the borehole and the drill bit must be cooled to extend its useful life. Both of these necessities are accomplished by the circulation of a fluid down through the drill string and up to the surface between the drill string and the wall of the borehole.

Once the borehole has been drilled to the desired depth, it may be desirable to isolate the separate areas, zones or formations traversed by the borehole. For extraction of fluids from formations, a conduit (casing) must be inserted into the borehole extending from the surface downward, and liners may be hung inside the casing.

At this point it becomes necessary to fill the annulus between the casing and the borehole wall or between the liner and casing with a material which will seal the annulus and provide structural support for the casing or liner. This is commonly referred to as primary cementing.

In order to obtain a good cementing job, it is necessary for the cement slurry to displace substantially all of the drilling mud

from the annulus. A reduced displacement efficiency arises from the fact that drilling fluids and cements are usually incompatible.

Non-displaced mud (mud still left in the borehole after cementing) and mud filter cake are major causes of unsatisfactory cement performance. Since the non-displaced mud and mud filter cake do not set or bond to the casing, the borehole wall or the set cement itself, the mud and filter cake do not support the casing properly and later can allow annular gas or liquid migration.

Wells frequently are drilled with water-base muds which contain oil as the internal emulsified phase. These muds are generally referred to as emulsion muds or emulsion drilling fluids. These emulsion muds are used, for example, to lower drilling torque and drag, and to prevent bit balling. The presence of the oil in the borehole, however, can even further reduce the displacement efficiency and subsequent cementing with a conventional water-base Portland cement slurry.

The drilling industry has sought to overcome the above problems by using a variety of techniques to displace the drilling fluid with cement, e.g., turbulent flow, casing movement (reciprocation/rotation), casing equipment (centralizers, flow diverters, mud cake scratchers), and special spacers and wash fluids, but these have had limited success. When a good cementing job is not obtained, it may be necessary to perforate the casing and squeeze cement under high pressure through the perforations into the annulus and try to fill the zones that were not properly cemented initially. Frequently, this squeeze cementing is not successful, and such failures may eventually lead to abandoning the hole.

One of the major objectives of a primary cementing is to obtain good zonal isolation in the annulus of the well. Effective zonal isolation is achieved by sealing the cement and borehole wall. The interface of the cement and borehole wall is usually an interface between the cement and drilling fluid filter cake which is the source of many cementing problems. Good zonal isolation can

only be achieved if the filter cake hardens, permanently bonds to the formation face and the cement, and provides hydraulic sealing.

Cementing of the annulus between an oil well casing and the surrounding borehole has been practised for over 90 years. Long ago, it was recognized that it would be advantageous to solidify drilling fluid in the annulus so as to reduce the cost of the cementing of the casings. Over the decades, various attempts have been made along this line as evidenced by the disclosures in USA patent specifications No. 2 649 160 and No. 3 887 009. However, such techniques, while presumably operable, have failed to achieve commercialization even after the passage of many years. Another attempt in this direction is described in USA patent specification No. 3 499 491, wherein Portland cement is used in an aqueous drilling fluid to produce a mud concrete. Portland cement, however, is very sensitive to the water/solids ratio. Even under ideal conditions, only small increases in the amount of solids results in a very viscous mass. On the other hand, only a slight decrease in the amount of solids results in a composition which sets up to give a very weak structure. These problems are amplified when attempting to use Portland cement in a drilling fluid. Thus, while this technique has been used commercially, it has serious drawbacks.

Slag, broadly, as a cementitious material is shown in USA patent specification No. 3 557 876.

It is an object of this invention to achieve the benefits of the presence of oil in an emulsion mud during drilling without the negative influence of oil on subsequent cementing.

It is a further object of this invention to avoid compatibility problems between drilling fluids and cementitious slurries used for borehole cementing.

It is a further object of this invention to provide a method for drilling and cementing which gives a good bond between the borehole and casing.

It is a further object of this invention to provide method for in-situ solidification of emulsion muds.

It is yet a further object of this invention to provide a universal fluid filter cake which can [illegible]ified.

To this end the method for drilling and cementing a well according to the present invention comprises:

drilling a borehole utilizing an oil-in-water emulsion drilling fluid, thus producing a used drilling fluid;

combining ingredients comprising water, blast furnace slag and an activator to produce a cementitious slurry;

disposing a pipe in the borehole;

passing the cementitious slurry down the pipe; and

displacing the cementitious slurry up into an annulus surrounding the pipe.

In another embodiment, the drilling fluid contains blast furnace slag.

In accordance with the invention the benefits of the oil in an emulsion drilling fluid are realized with improved, not deteriorated cementing integrity.

As used herein, the term 'drilling fluid' means water-based fluid which also contains at least one other additive such as viscosifiers, thinners, dissolved salts, solids from the drilled formations, solid weighting agents to increase the fluid density, formation stabilizers to inhibit deleterious interaction between the drilling fluid and geologic formations, and additives to improve the lubricity of the drilling fluid.

The term 'cementitious material' means blast furnace slag, i.e., a material which, on contact with water and/or activators, hardens or sets into a solidified composition.

The term 'emulsion mud' means a water-based drilling fluid containing oil wherein oil is the internal phase and water is the external or continuous phase. The term oil includes mineral oil, diesel oil, crude oil, synthetic oil, petroleum oil, vegetable oil or esters of vegetable and mineral oils. The esters may include nonionic or ionic detergents.

A slurry of this cementitious material and the component or components which cause it to harden is referred to herein as a 'cementitious slurry'.

The term 'universal fluid' is used herein to designate those emulsion mud compositions containing blast furnace slag, which compositions are suitable for use as a drilling fluid, and which compositions thereafter, for the purpose of practising this invention, have additional blast furnace slag and/or activators such as accelerators added to give a cementitious slurry.

The term 'pipe' means either a casing or a liner.

The term 'primary cementing' refers to any cementing operation wherein a cementitious slurry is passed into an annulus surrounding a pipe and thus encompasses both the cementing of casings wherein the annulus is between the casing and the borehole wall and the cementing of liners where the annulus is between the liner and the casing.

The present invention further comprises a method for drilling and cementing a well which comprises:

combining blast furnace slag having a particle size between 2 000 and 15 000 cm^2/g with an oil-in-water emulsion drilling fluid, the blast furnace slag being present in an amount between 2.8 and 280 kg/m^3 of the drilling fluid plus blast furnace slag;

utilizing the drilling fluid in a well drilling operation to drill a borehole and to produce a used drilling fluid;

combining additional blast furnace slag and an activator with the used drilling fluid to produce a cementitious slurry;

disposing a pipe in the borehole;

passing the cementitious slurry down the pipe; and

displacing the cementitious slurry up into an annulus surrounding the pipe.

The present invention further comprises a method for drilling and cementing a well which comprises:

drilling a borehole utilizing an oil-in-water emulsion drilling fluid, thus producing a used drilling fluid;

combining blast furnace slag and an activator with a portion of the used drilling fluid to produce a cementitious slurry;

disposing a pipe in the borehole;

passing the cementitious slurry down the pipe; and

displacing the cementitious slurry up into an annulus surrounding the pipe.

The drilling can be carried out using a conventional emulsion drilling fluid or by utilizing a universal fluid as described herein.

Generally, in the universal fluid embodiment, the starting material to which the cementitious material (blast furnace slag) is added to give the universal drilling fluid used in this invention is a conventional drilling fluid.

It is sometimes desired that the water-based drilling fluids use water-containing dissolved salts, particularly sodium chloride. In these instances, 0.1 to 26 wt%, preferably 3 to 10 wt% sodium chloride may be used. One suitable source is to use seawater or a brine solution simulating seawater. Particularly in the embodiment using slag, the strength of the resulting cement is actually enhanced which is contrary to what would be expected in view of the intolerance of Portland cement to brine. Various salts, preferably organic salts, are suitable for use in the drilling fluid used in this invention in addition to, or instead of NaCl, including, but not limited to, NaBr, KCl, $CaCl_2$, $NaNO_3$, $NaC_2H_3O_2$, $KC_2H_3O_2$, $NaCHO_2$ and $KCHO_2$ among which sodium chloride is preferred, as noted above. These salts can be used, if desired, up to the saturation point under the conditions employed.

A typical drilling fluid formulation to which cementitious material may be added to form a universal drilling fluid is as follows: 10-20 wt% salt, 23-28 kg/m^3 bentonite, 11-17 kg/m^3 carboxymethyl starch (fluid loss preventor), sold under the trade name "BIOLOSE" by Milpark Drilling Fluids, 1-3 kg/m^3 partially hydrolyzed polyacrylamide (PHPA) which is a shale stabilizer, sold under the trade name "NEWDRIL" by Milpark Drilling Fluids, 3-4

kg/m^3 CMC sold under the trade name "MILPAC" by Milpark Drilling Fluids, 85-200 kg/m^3 drill solids, and 0-715 kg/m^3 barite.

The oil is generally present in the drilling fluid in an amount between 0.1 and 10, preferably between 1.5 and 7, more preferably, between 2 and 7 volume percent based on the total volume of drilling fluid.

Thus, the universal fluid makes possible a method for drilling and cementing a well comprising preparing a universal fluid by mixing an emulsion drilling fluid and blast furnace slag; drilling a borehole with the universal fluid and laying down a settable filter cake on the wall of the borehole during drilling of the well; adding additional blast furnace slag and/or activators and introducing the thus-formed cementitious slurry into the borehole and into an annulus surrounding a pipe where it hardens and sets up forming a good bond with the filter cake which filter cake, by itself, actually hardens with time because of the presence of cementitious material therein. This hardening is facilitated by any accelerators which may be present in the cementitious slurry and which migrate by diffusion and/or filtration into the filter cake.

Because the drilling fluid becomes a part of the final cementitious slurry, the amount of used drilling fluid which must be disposed of is greatly diminished.

In another embodiment of this invention, most or all of the components of the drilling fluid are chosen such that they have a function in the cementitious material also. The following Tables 1 and 2 illustrates the uniqueness of such drilling fluid formulations and cementitious slurry formulations.

Table 1. Information on functions of additives in a drilling fluid.

Additive	Primary function	Secondary function
Synthetic polymer[1]	Fluid loss control	
Starch[2]	Fluid loss control	Viscosity control
Biopolymer[3]	Viscosity	
Silicate	Viscosity	Shale stabilizer
Carbohydrate polymer[4]	Deflocculant	
Barite[5]	Density	
Bentonite[6]	Fluid loss control	
Clay/Quartz dust[7]	--	--
Slag[8]	Cuttings stabilizer	--
Lime[9]	Shale stabilizer	Alkalinity
PECP[10]	Cuttings/Well-bore stabilizer	Fluid loss
NaCl	Shale stabilizer	—
Oil	Lubricant	Anti-balling

Table 2. Information on functions of additives in a cementitious slurry.

Additive	Primary function	Secondary function
Synthetic polymer[1]	Fluid loss control	Retarder
Starch[2]	Fluid loss control	Retarder
Biopolymer[3]	Viscosity	Retarder
Silicate	Accelerator	--
Carbohydrate polymer[4]	Retarder	Deflocculant
Barite[5]	Density concentration	Solids
Bentonite[6]	Fluid loss control	Solids concentr.
Clay/Quartz dust[7]	Solids concentration	
Slag[8]	Cementitious concentration	Solids
Lime[9]	Accelerator concentration	Solids
PECP[10]	Retarder	Rheological control
NaCl	—	—
Oil	--	--

[1]A synthetic polymer manufactured by SKW Chemicals Inc. under trade name "POLYDRILL", for instance.

[2]Starch made by Milpark Inc. under the trade name "PERMALOSE", for instance.

[3]"BIOZAN", a biopolymer made by Kelco Oil Field Group, Inc., for instance.

[4]A water-soluble carbohydrate polymer manufactured by Grain Processing Co. under the trade name "MOR-REX", for instance.

[5]Barite is $BaSO_4$, a drilling fluid weighting agent.

[6]Bentonite is clay or colloidal clay thickening agent.

[7]A clay/quartz solid dust manufactured by MilWhite Corp. under the trade name "REVDUST", for instance.

[8]Blast furnace slag manufactured by Blue Circle Cement Co. under the trade name "NEWCEM" is suitable.

[9]CaO.

[10]Polycyclicpolyetherpolyol, as described in USA patent specification No. 5 058 679.

The preferred blast furnace slag used in this invention is a high glass content slag produced by quickly quenching a molten stream of slag at a temperature of between 1400 °C and 1600 °C through intimate contact with large volumes of water. Quenching converts the stream into a material in a glassy state having hydraulic properties. At this stage it is generally a granular material that can be easily ground to the desired degree of fineness. Silicon dioxides, aluminium oxides, iron oxides, calcium oxide, magnesium oxide, sodium oxide, potassium oxide, and sulphur are some of the chemical components in slags. Preferably, the blast furnace slag used in this invention has a particle size such that it exhibits a specific surface area between 2 000 cm^2/g and 15 000 cm^2/g and more preferably, between 3 000 cm^2/g and 15 000 cm^2/g, even more preferably, between 4 000 cm^2/g and 9 000 cm^2/g, most preferably between 4 000 cm^2/g and 8 500 cm^2/g. In each instance the specific surface area or surface area is the Blaine specific surface area. An available blast furnace slag which fulfils these requirements is marketed under the trade name "NEWCEM" by the Blue Circle Cement Company. This slag is obtained from the Bethlehem Steel Corporation blast furnace at Sparrows Point, Maryland.

A usual blast furnace slag composition range in weight percent is: SiO_2, 30-40; Al_2O_3, 8-18; CaO, 35-50; MgO, 0-15; iron oxides, 0-1; S, 0-2 and manganese oxides, 0-2. A typical specific example is: SiO_2, 36.4; Al_2O_3, 16.0; CaO, 43.3; MgO, 3.5; iron oxides, 0.3; S, 0.5; and manganese oxides, < 0.1.

Blast furnace slag having relatively small particle size is frequently desirable because of the greater strength it imparts in many instances to a final cement. Characterized in terms of particle size the term "fine" can be used to describe particles with a specific surface area between 4 000 and 7 000 cm^2/g, corresponding to between 16 and 31 micrometer in size; "microfine" can be used to describe those particles with a specific surface area between 7 000 and 10 000 cm^2/g that correspond to particles of 5.5-16 micrometer in size, and "ultrafine" can be used to describe particles with a specific surface area over 10 000 cm^2/g that correspond to particles 5.5 micrometer and smaller in size. Small particle size blast furnace slags are available from Blue Circle Cement Co., Koch Industries, Tulsa, Oklahoma, under the trade name "WELL-CEM", and from Geochem under the trade name "MICROFINE MC100".

However, it is very time consuming to grind blast furnace slag to these particles sizes. It is not possible to grind blast furnace slag in a manner where particles are entirely one size. Thus, any grinding operation will give a polydispersed particle size distribution. A plot of particle size versus percent of particles having that size would thus give a curve showing the particle size distribution.

In accordance with a preferred embodiment of this invention a blast furnace slag having a polydispersed particle size distribution exhibiting at least two nodes on a plot of particle size versus percent of particles in that size is utilized. It has been found that if only a portion of the particles are in the ultrafine category, the remaining, indeed the majority, of the slag can be ground more coarsely and still give essentially the same result as is obtained from the more expensive grinding of all of the blast furnace slag to an ultrafine state. Thus, a grinding process which will give at least 5% of its particles falling in a size range between 1.9 and 5.5 micrometer offers a particular advantage in economy and effectiveness. More preferably, between 6 and 25wt% would fall in the 1.9 to 5.5 micrometer range. The most

straightforward way of obtaining such a composition is simply to gr[illegible] minor portion of the blast furnace slag to an ultrafine cor[illegible]ix the resulting powder with slag ground under less sever[illegible]s. Even with the less severe conditions there would be some particles in the fine, microfine or ultrafine range. Thus, only a minority, i.e., as little as 4wt% of the slag, would need to be ground to the ultrafine particle size. Generally, 5 to 25wt%, more preferably 5 to 10wt% can be ground to the ultrafine particle size and the remainder ground in a normal way thus giving particles generally in a size range of greater than 11 micrometer, the majority being in the 11 to 31 micrometer range.

Suitable activators include lithium hydroxide, lithium carbonate, sodium silicate, sodium fluoride, sodium silicofluoride, magnesium hydroxide, magnesium oxide, magnesium silicofluoride, zinc carbonate, zinc silicofluoride, zinc oxide, sodium carbonate, titanium carbonate, potassium carbonate, sodium hydroxide, potassium hydroxide, potassium sulphate, potassium nitrite, potassium nitrate, calcium hydroxide, sodium sulphate, copper sulphate, calcium oxide, calcium sulphate, calcium nitrate, calcium nitrite, and mixtures thereof. A mixture of caustic soda (sodium hydroxide) and soda ash (sodium carbonate) is preferred because of the effectiveness and ready availability. When mixtures of alkaline agents such as caustic soda and soda ash are used the ratio can vary rather widely since each will function as an accelerator alone. Preferably, about 3 to 57 kg/m^3 of caustic soda, more preferably 6 to 18 kg/m^3 of caustic soda are used in conjunction with from 6 to 143 kg/m^3, preferably 6 to 60 kg/m^3 of soda ash.

The preferred sequence for universal fluid in this embodiment of the invention is to prepare the drilling fluid containing a portion of the total slag to be utilized, carry out the drilling operation, dilute the fluid, add the remainder of the slag, add the activator and utilize the cement for its intended purpose such as cementing a casing.

Generally, the used universal fluid will be diluted and more cementitious material added as well as the reactive second

component when the cementitious slurry is formed. Dilution of the drilling fluid is usually needed for control of the density and rheology of the final cementitious slurry. The amount of dilution can vary widely depending on the desired application. Generally, the fluid will be diluted with from 5 to 200%, preferably 5 to 100%, more preferably 5 to 50% by volume (water in the case of a water-based fluid) per volume of initial drilling fluid. In one particularly preferred embodiment, the dilution is such that on addition of the cementitious component (or in the case of the universal fluid addition of the remaining cementitious component) the final density will be between 30% less and 70% more than the original density, preferably between 15% less and 25% more, most preferably, essentially the same, i.e., varying by no more than ±5 wt%. This is particularly valuable in an operation where there is a small difference between the pressure needed to prevent blowout and the pressure which would rupture or fracture the formation through which drilling has taken place.

The dilution fluid can be the same or different from that used to make the drilling fluid initially. In the case of brine-containing fluids the dilution fluid will generally be brine also. This is of particular benefit in offshore drilling operations where fresh water is not readily available but seawater is abundant.

Preferably, the dilution is carried out "on the fly" by adding dilution fluid to a flowing stream of the used drilling fluid and thereafter adding the additional ingredients.

In some instances it is desirable to sequence the incorporation of ingredients into the drilling fluid. For instance, with slag as the cementitious component, it may be desirable to introduce and mix thinners and/or retarders and activators and thereafter introduce the slag. This is particularly true if mixed metal hydroxides are used in the drilling fluid to impart thixotropic properties. The mixed metal hydroxides provide better solids suspension. This, in combination with the settable filter cake provided in the technique of this invention, greatly enhances the cementing in a restricted annulus. The mix d metal hydroxides

are particularly effective in drilling fluids containing clay such as sodium bentonite. Preferred systems thickened in this way contain from 3 to 57 kg/m^3 of clay such as bentonite, preferably 6 to 43 kg/m^3, most preferably 20 to 34 kg/m^3. The mixed metal hydroxides are generally present in an amount between 0.3 and 6 kg/m^3 of total drilling fluid, preferably between 0.3 and 4 kg/m^3, most preferably between 2 and 4 kg/m^3. Mixed metal hydroxides are known in the art and are trivalent metal hydroxide-containing compositions such as $MgAl(OH)_{4.7}Cl_{0.3}$. They conform essentially to the formula

$$Li_m D_d T(OH)_{(m+2d+3+na)} A^n{}_a$$

where

m represents the number of Li ions present; the amount being between 0 and 1;

D represents divalent metals ions; with

d representing the amount of D ions between 0 and about 4;

T represents trivalent metal ions;

A represents monovalent or polyvalent anions of valence n, other than OH^-, with a being the amount of A' anions; and

where (m+2d+3+na) is equal to or greater than 3.

A more detailed description can be found in USA patent specification No. 4 664 843.

The mixed metal hydroxides in the drilling fluid, in combination with blast furnace slag, tend to set to a cement having considerable strength in a comparatively short time, i.e., about one-half hour at temperatures as low as 38 °C. This can be a major asset in some applications. In such instances, a thinner such as a lignosulfate is preferably added before adding slag. However, one of the advantages of this invention is that it reduces or eliminates the need for additives to control free water or solids suspension. The activator or activators can be added either before or after the addition of the additional blast furnace slag.

In some instances, it may be desirable to use a material for a particular effect along with the activator even though it may also act as a retarder. For instance, a chromium lignosulphonate may be

used as a thinner along with the activator even though it also functions as a retarder.

Other suitable thinners include chrome-free lignosulphonate, lignite, sulphonated lignite, sulphonated styrene maleic-anhydride, sulphomethylated humic acid, naphthalene sulphonate, a blend of polyacrylate and polymethacrylate, an acrylamideacrylic acid copolymer, phenol sulphonate, dodecylbenzene sulphonate, and mixtures thereof.

The amount of slag present in the universal fluid is generally between 3 and 300 kg/m^3 of final drilling fluid, preferably between 30 and 240 kg/m^3, most preferably between 60 and 150 kg/m^3.

The total amount of cementitious material in the cementitious slurry will typically be between about 60 and about 1 700 kg/m^3, preferably between 290 and 1 450 kg/m^3, most preferably between 450 and 1 000 kg/m^3.

Conventional additives which can be added include accelerators, retarders, and other known components of cementitious materials.

Suitable fluid loss additives found in drilling fluids include bentonite clay, carboxymethylated starches, starches, carboxymethyl cellulose, synthetic resins such as "POLYDRILL" by SKW Chemicals, sulphonated lignite, lignite, lignin, or tannin compounds. Weight materials include barite, calcium carbonate, hematite and MgO, for example. Shale stabilizers that are used in drilling fluids include hydrolyzed polyacrylonitrile, partially hydrolyzed polyacrylamide, salts including NaCl, KCl, sodium or potassium formate, sodium or potassium acetate, polyethers and polycyclic and/or polyalcohols. Viscosifying additives can be used such as biopolymers, starches, attapulgite and sepiolite. Additives are also used to reduce torque. Suitable thinners such as chrome and chrome free lignosulphonates, sulphonated styrene maleic-anhydride and polyacrylate may also be used depending upon the mud type and mud weight. Lubricating additives include ionic and nonionic detergents and the oil used to mole the emulsion drilling fluid (diesel, mineral oil, vegetable oil, synthetic oil), for instance.

Alkalinity control can be obtained with KOH, NaOH or CaO, for instance. In addition, other additives such as corrosion inhibitors, nut hulls etc. may be found in a typical drilling fluid. Of course, drill solids including such minerals as quartz and clay minerals (smectite, illite, chlorite, kaolinite, etc.) may be found in a typical mud.

In yet another embodiment of this invention the drilling process is carried as described hereinabove with a universal fluid to produce a borehole through a plurality of strata thus laying down a filter cake. Prior to the cementing operation an activator is passed into contact with the filter cake, for instance by circulating the activator down the drill string and up the annulus between the drill string and the filter cake, or else the drill string is removed and the casing inserted and the activator circulated down the casing and up the annulus. As used herein 'down' as it relates to a drill string or casing, means in a direction toward the farthest reach of the borehole even though in rare instances the borehole can be disposed in a horizontal position. Similarly, 'up' means back toward the beginning of the borehole. Preferably, the circulation is carried out by using the drill string, this being the benefit of this embodiment of the invention whereby the filter cake can be "set" to shut off gas zones, water loss, or to shut off lost circulation in order to keep drilling without having to remove the drill string and set another string of casing. This can also be used to stabilize zones which may be easily washed-out (salt zones wherein the salt is soluble in water, for instance) or other unstable zones. After the drilling is complete the drill string is removed, and the cementing carried out as described hereinabove. This can be accomplished by circulating a separate fluid containing the activator or by adding an activator such as an alkali as described hereinabove to the drilling fluid.

Conventional spacers may be used in the above described sequence. Also, any left over fluid having activators therein may be displaced out of the borehole by the next fluid and/or a spacer fluid and stored for subsequent use or disposal.

Cementing can be done in accordance with this invention without spacers or the plugs normally used. The cement cementitious slurry can be displaced by direct contact with a displacement fluid such as seawater.

In this embodiment where the filter cake is "set", the activator can be any of the alkaline activators referred to hereinabove such as a mixture of sodium hydroxide and sodium carbonate.

The invention will now be described in more detail with reference to the examples.

Example 1 shows the presence of the oil to create an emulsion mud has no adverse effect on the mud properties and that on addition of the hydraulic material, blast furnace slag, and the activators, a cement is obtained which has essentially the same compressive strength when made with the emulsion mud as it has with the oil free mud. The tests are done on two drilling fluid formulations, formulation 1 did not contain oil and formulation 2 does contain oil, and for each drilling fluid formulation two cement compositions are tested. The compositions and the results are shown in the below Table 3.

Table 3. Results of the tests relating to example 1.

Drilling Fluids	Formulation 1	Formulation 2
Seawater/NaCl (90%/10%) (ml)	263.8	263.8
Bentonite[1] (g)	20.0	20.0
Rev Dust[2] (g)	25.0	25.0
MOR-REX[3] (g)	1.5	1.5
Lime (g)	4.0	4.0
Barite[4] (g)	158.6	158.6
Biozan[5] (g)	1.5	1.5
Permalose[6] (g)	6.0	6.0
Polydrill[7] (g)	6.0	6.0
Polyalcohoi[8] (g)	36.9	36.9
Mineral oil % v/v	-	3.0
Plastic Viscosity (mPa.s)	40	43
Yield Point (Pa)	12	11
10 Minute Gel (Pa)	5.3	5.8
First Cement Formulation		
NEWCEM[9] (kg/m^3)	570	570
KOH (kg/m^3)	14	14
Sodium Carbonate (kg/m^3)	14	14
Uniaxial Compressive Strength (MPa) after 48 hours at 65°C	7.7	7.8
Second Cement Formulation		
NEWCEM[9] (kg/m^3)	143	143
KOH (kg/m^3)	14	14
Sodium Carbonate (kg/m^3)	14	14
Uniaxial Compressive Strength (MPa) after 48 hours at 65 °C	0.9	0.8

[1]Bentonite is clay or colloidal clay thickening agent.

[2]Rev Dust is a trade name for clay/quartz solid dust manufacturing by Milwhite Corp.

[3]MOR-REX is a trade name for water-soluble carbohydrate polymer manufactured by Grain Processing Company.

[4]Barite is BaSO4 a drilling fluid weight material.

[5]Biozan is a biopolymer manufactured by Kelco Oil Field Group, Inc.
[6]Permalose is a trade name for starch by Milpark, Inc.
[7]Polydrill is a trade name for synthetic polymer manufactured by SKW Chemicals Inc.
[8]Polyalcohol is PECP.
[9]Trade name for blast furnace slag of about 5 500 specific surface area sold under the trade name NEWCEM by Blue Circle Cement Company.

The data of example 2 in Table 4 show in a different mud the same indication that the presence of the oil to create the emulsion mud does not adversely affect the mud properties. A comparison of formulations 4 and 5 shows that comparable compressive strength is obtained in the cement made using the emulsion mud as compared with that made from the oil free mud. These formulations did not contain an activator and thus set very slowly. Of course, the formulation with no blast furnace slag does not form a cement.

Table 4. Compositions of drilling fluid formulations and results of example 2.

20% NaCl/PHPA mud from field	Formulation 3	Formulation 4	Formulation 5
Mineral Oil (% v/v)	-	-	3
Plastic Viscosity (mPa.s)	30	35	38
Yield Point (Pa)	4.8	7.2	8.1
10 second gel (Pa)	1.4	1.9	2.4
10 minute gel (Pa)	5.3	3.8	4.3
NEWCEM[1] (kg/m^3)	-	114	114
HPHT[2] (ml) 93 °C	12.8	16.4	15.2
Uniaxial Compressive Strength (MPa) 65 °C after 28 days	0	0.72	0.66

[1] Trade name for blast furnace slag of about 5 500 specific surface area sold under the trade name NEWCEM by Blue Circle Cement Company.

[2] High pressure, high temperature water loss.

While this invention has been described in detail for the purpose of illustration, it is not to be construed as limited thereby, but is intended to cover all the changes and modifications within the spirit and scope thereof.

CLAIMS

1. A method for drilling and cementing a well, comprising:
drilling a borehole utilizing an oil-in-water emulsion drilling fluid, thus producing a used drilling fluid;
combining ingredients comprising water, blast furnace slag and an activator to produce a cementitious slurry;
disposing a pipe in the borehole;
passing the cementitious slurry down the pipe; and
displacing the cementitious slurry up into an annulus surrounding the pipe.

2. The method according to claim 1 wherein the water of the cementitious slurry contains dissolved salts.

3. The method according to claim 2 wherein the water of the cementitious slurry is seawater.

4. The method according to claim 1 wherein between 5 and 25 wt% of the blast furnace slag has an ultrafine particle size.

5. The method according to claim 1 wherein the cementitious slurry contains seawater, the activator is a mixture of sodium hydroxide and sodium carbonate, and wherein between 5 and 25 wt% of the blast furnace slag has an ultrafine particle size.

6. The method according to claim 1 wherein the activator is a mixture of sodium hydroxide and sodium carbonate, the sodium hydroxide being used in an amount between 6 and 18 kg/m^3 and the sodium carbonate is used in an amount between 6 and 60 kg/m^3, and wherein the cementitious slurry contains between 430 and 1 000 kg/m^3 of the cementitious material.

7. The method according to claim 1 wherein the oil is mineral oil and is present in an amount between 0.1 and 10 volume percent based on the volume of the drilling fluid.

8. A method for drilling and cementing a well, comprising:
combining blast furnace slag having a particle size between 2 000 and 15 000 cm^2/g with an oil-in-water emulsion drilling

fluid, the blast furnace slag being present in an amount between 2.8 and 28[illegible]^3 of the drilling fluid plus blast furnace slag;

utili[illegible]illing fluid in a well drilling operation to drill a borehole and to produce a used drilling fluid;

combining additional blast furnace slag and an activator with the used drilling fluid to produce a cementitious slurry;

disposing a pipe in the borehole;

passing the cementitious slurry down the pipe; and

displacing the cementitious slurry up into an annulus surrounding the pipe.

9. The method according to claim 8 wherein the activator is a mixture of sodium hydroxide and sodium carbonate and the displacement fluid comprises seawater.

10. The method according to claim 9 wherein the oil is present in an amount between 2 and 4 volume percent based on the volume of the drilling fluid.

11. The method according to claim 8 wherein the final cementitious slurry contains between 430 and 1 000 kg/m^3 of the blast furnace slag.

12. A method for drilling and cementing a well, comprising:

drilling a borehole utilizing an oil-in-water emulsion drilling fluid, thus producing a used drilling fluid;

combining blast furnace slag and an activator with a portion of the used drilling fluid to produce a cementitious slurry;

disposing a pipe in the borehole;

passing the cementitious slurry down the pipe; and

displacing the cementitious slurry up into an annulus surrounding the pipe.

13. The method according to claim 12 wherein the water of the drilling fluid contains water with dissolved salts.

14. The method according to claim 13 wherein the water of the drilling fluid is seawater.

15. The method according to claim 12 wherein between 5 and 25 wt% of the blast furnace slag has an ultrafine particle size.

16. The method according to claim 12 wherein the drilling fluid contains seawater, the activator is a mixture of sodium hydroxide and sodium carbonate, and wherein between 5 and 25 wt% of the blast furnace slag has an ultrafine particle size.

17. The method according to claim 12 wherein the oil is present in an amount between 0.1 and 10 volume percent based on the volume of the drilling fluid.

18. The method according to claim 12 wherein the oil is present in amount between 1.5 and 7 volume percent based on the volume of the drilling fluid.

19. The method according to claim 12 wherein the oil is mineral oil and is present in an amount between 2 and 4 volume percent based on the volume of the drilling fluid.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 93/02930

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 E21B33/13 C09K7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 E21B C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US,A,5 213 160 (SHELL) 25 May 1993	1-3,8, 12-14
A	see column 2, line 14 - column 6, line 16	4,7,10, 11,15, 17-19
A	US,A,5 058 679 (SHELL) 22 October 1991 see column 2, line 5 - column 4, line 37 see column 14, line 39 - column 15, line 40	1-6,8,9, 11,12
A	US,A,3 899 431 (MARATHON OIL) 12 August 1975 see column 2, line 27 - column 3, line 45	1,7,8, 10, 12-14, 16-19

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
14 January 1994	20.01.94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	DE PAEPE, P

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PCT/EP 93/02930

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,3 557 876 (THE WESTERN COMPANY OF NORTH AMERICA) 26 January 1971 cited in the application see the whole document -----	1-19

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 93/02930

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-5213160	25-05-93	NONE	
US-A-5058679	22-10-91	NONE	
US-A-3899431	12-08-75	NONE	
US-A-3557876	26-01-71	NONE	